

# Chapter 33

## CARMIE: A Conversational Medication Assistant for Heart Failure

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### ABSTRACT

*The incidence of chronic diseases is increasing and monitoring patients in a home environment is recommended. Noncompliance with prescribed medication regimens is a concern, especially among older people. Heart failure is a chronic disease that requires patients to follow strict medication plans permanently. With the objective of helping these patients managing information about their medicines and increasing adherence, the personal medication advisor CARMIE was developed as a conversational agent capable of interacting, in Portuguese, with users through spoken natural language. The system architecture is based on a language parser, a dialog manager, and a language generator, integrated with already existing tools for speech recognition and synthesis. All modules work together and interact with the user through an Android application, supporting users to manage information about their prescribed medicines. The authors also present a preliminary usability study and further considerations on CARMIE.*

### INTRODUCTION

As modern Medicine developed, the consumption of pharmacological drugs has raised exponentially (Sullivan, Behncke, & Purushotham, 2010). With the multiplicity of medication regimens, modern Pharmacology brought large amounts of information to be managed by patients and healthcare staff. At the same time, and in part due to the world population ageing, the number of patients suffering from chronic

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illnesses is growing (Giles, 2004). Such diseases usually demand treatments with numerous pharmacological prescriptions that require strict medication management. One of these diseases is heart failure (HF), presenting high prevalence, especially in the USA and Europe, and significant health expenditure due to frequent patient hospitalization and readmissions (Ziaeiian & Fonarow, 2016). Typically, senior HF patients need around 13 different drugs per day, at home, of which a significant number are not prescribed (Ewen et al., 2015). With such complex medication regimens for HF, patients spend a lot of effort gathering the information required to successfully manage their disease, but still having trouble in keeping track of this information (Ferguson et al., 2010). Compliance is also an important outcome predictor among patients with chronic diseases like HF. In general, medication adherence is remarkably lower than self-reported adherence (Nieuwenhuis, Jaarsma, van Veldhuisen, & van der Wal, 2012). A study (Cabral & Silva, 2010) showed that the poor adherence to therapeutic prescriptions is a major problem of public health in Portugal, where the main reasons for nonadherence are the patient's fear of asking questions to their doctors, and the difficulty in listening to or understanding caregivers' explanations on how to deal with the prescribed regimen. As slight improvements in functional capacity are of the utmost importance to HF patients, prescribed treatments should be taken seriously. Existing HF home-monitoring programs have proved to be helpful with reduced readmissions and prolongation of survival (Stewart & Horowitz, 2002). However, due to the unaffordable costs and insufficient number of medical personnel, the required specialized healthcare staff cannot offer daily home-assistance. It was suggested by Ferguson et al. (2010) that the use of automated intelligence assistance to manage medication can foster patient survival. Therefore, there is a need for automated systems, for health communication and management, that can provide intelligence assistance to HF patients within a home health environment.

This work aims to encompass the next technological step towards a virtual personal medication advisor: a conversational system capable of interacting with users through natural language, mostly voice, to help them manage their condition and the prescribed medication regimens. A virtual medication advisor shares its guidelines with information therapy, which supports that providing specific evidence-based medical information to certain patients at the right time can help them making positive behavior changes and improving self-consciousness of healthcare (Mettler & Kemper, 2002). It is expected that the conversational assistant described in this work can bring together the advantages of information therapy and mobile technologies, improving disease outcomes through a patient centered approach.

The smartphone-based assistant developed, named CARMIE, aims to deliver information and knowledge-based advice to help chronic diseases' patients managing complex prescription regimens. In-home medication monitoring is facilitated by providing personalized intelligence assistance on posology, interactions, indications, and adverse reactions. Another objective is to motivate the user through interactive dialogue and cues, trying to increase medication adherence. It is expected that, in result of using the proposed system, well-informed and home-monitored patients will be showing increased patient survival, as well as reduced re-hospitalization and mortality rates, in addition to allowing better responsiveness and distribution of work time among healthcare staff. Patients with chronic diseases will be able to live more independently with greater compliance, satisfaction, and understanding of their therapeutic regimens.

As an initial approach, CARMIE was developed in European Portuguese, opening an unexplored path on the integration of intelligence assistance in Portuguese healthcare. Furthermore, the scope of the conversational assistant developed is restricted to medication regimens for HF, due to its well-defined pharmacological practices, which greatly depend on self-care and self-management to lengthen patient survival (McMurray et al., 2012). One of the particularities of this project, lies in the fact that the phar-

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